## 1. Physical Oceanography and Underway Environmental Observations; submitted by David A. Demer (Leg I), Roger Hewitt (Leg II), Pierre Malan (Leg I), Rob Rowley (Legs I and II).

**1.1 Objectives:** Objectives were to 1) collect and process physical oceanographic data in order to identify and map oceanographic frontal zones; and 2) collect and process environmental data underway in order to describe sea surface and meteorological conditions experienced during the conduct of the surveys. These data may be used to describe the physical circumstances associated with various biological observations as well as provide a detailed record of the ship's movements and encountered environmental conditions.

**1.2 Accomplishments:** Two series of observations were collected. The first included vertical profiles of temperature, depth, and oxygen as well as discrete water samples from fixed stations. The second included underway measurements of sea surface temperature, salinity and fluorescence as well as air temperature, pressure, relative humidity, wind speed and direction, indexed to date, time and ship's position.

During the CCAMLR-2000 survey on Leg I, 35 CTD/carousel stations were conducted (Figure 2 in Introduction section). Another 12 CTD/carousel stations were conducted later in Leg I in support of the inshore survey near Cape Shirreff (Figure 3 in Introduction and Section 5). During the AMLR survey (AMLR00D) on Leg II, 98 CTD/carousel stations were conducted (Figure 4 in Introduction). During the CCAMLR-2000 survey, five water samples were collected at each station for salinity checks using a calibrated Guildline Autosal; four water samples were collected at each station for determination of chlorophyll concentrations. During both Legs I (39 days) and II (26 days), underway data were collected and archived. Augmented with GPS navigational information and output from the ship's gyro compass, these data provided complete coverage of surface environmental conditions encountered throughout the CCAMLR and AMLR study areas.

All CTD/carousel casts were made with a Sea-Bird SBE-9/11 PLUS CTD/carousel water sampler. During the CCAMLR-2000 survey CTD profiles extended to 1000m (or to within a few meters of the ocean floor when the depth was less than 1000m); during the AMLR survey CTD profiles extended to 750m water depth. A Data Sonics altimeter was used to guide the CTD/carousel to within 5m of the bottom on the shallow stations. Downtrace (24 scans/second) and uptrace (6 scans/second) CTD data for each station were recorded separately. All carousel bottles were fired during the upcast. Raw CTD data were corrected for time-constant differences in the primary and oxygen sensors. Parameters were then derived and binned to produce 1-meter depth-averaged profiles for analysis. Ocean Data View (version 5.0 developed by Dr. Reiner Schlitzer, Alfred Wegener Institut, and reviewed by Brown, 1998) was used to visualize the data and support tentative conclusions.

The underway data collection system consisted of 1) digital outputs from a Seabird SBE21 thermosalinograph, a Coastal Environmental Systems WeatherPak 2000, a Furuno GPS Navigator GP-30-35, the ship's GPS system, and the ship's gyro compass; 2) analog outputs from a Turner Designs Model 10-005R fluorometer; 3) a Fluke Data Bucket used for analog to

digital signal conversion; 4) a Digi 16-port serial adapter; and 5) a Windows NT computer running the Shipboard Computer System (SCS) Version 2.3 software developed by the Software Engineering Division of NOAA's Marine and Aviation Operations, Silver Spring, Maryland.

### 1.3 Results and Tentative Conclusions:

**CCAMLR-2000 survey.** Oceanographic fronts located at the central axis and southern boundary of the Antarctic Circumpolar Current were evident on all three major transects across the Scotia Sea conducted by the R/V *Yuzhmorgeologiya* (Figure 1.1). These data will be combined with that collected by observers on the other ships participating in the CCAMLR-2000 survey in order to generate a more detailed description of the physical oceanography of the Scotia Sea during January-February 2000.

**Cape Shirreff survey.** A portion of the oceanographic front described below was evident on the three cross-sections observed near Cape Shirreff.

**AMLR survey.** As in past years, the dominant physical feature mapped in the vicinity of the South Shetland Islands during the AMLR00D survey was the oceanographic frontal region running parallel to the continental shelf break north of the archipelago. Stations with similar temperature/salinity (T/S) relationships were grouped and classified into five water zones, designated I through V. The frontal region marks the merge of coastal water flowing through the Bransfield Strait and the Antarctic Circumpolar Current flowing through Drakes Passage. The water zones, defined by characteristic T/S curves (Figure 1.2), may consist of more than one water mass. Thus, Water Zone I is the oceanic water of the Drake Passage and is defined by the following characteristics: warm, low salinity surface water; strong sub-surface temperature minimum (called "Winter Water" at approximately –1ºC and salinity of 34.0ppt.); and a distinct T/S maximum near 500m (called "Circumpolar Deep Water" or CDW). In the Bransfield Strait, Water Zone IV is found with bottom waters around –1ºC, and subsurface extremes that are far less prominent. In between, there are transition zones where adjacent water zones mix. The water zones were operationally defined as:

| | **T/S Relationship** | | |
|---|---|---|---|
| | **Left** | **Middle** | **Right** |
| **Water Zone I (ACW)** | **Pronounced V shape with V at ≤0ºC** | | |
| Warm, low salinity water, with a strong subsurface temperature minimum, Winter Water, approximately -1ºC, 34.0ppt salinity) and a temperature maximum at the core of the CDW near 500m. | 2 to >3ºC at 33.7 to 34.1ppt | ≤0ºC at 33.3 to 34.0ppt | 1 to 2ºC at 34.4 to 34.7ppt (generally >34.6ppt) |
| **Water Zone II (Transition)** | **Broader U-shape** | | |
| Water with a temperature minimum near 0ºC, isopycnal mixing below the temperature minimum and CDW evident at some locations. | 1.5 to >2ºC at 33.7 to 34.2ppt | -0.5 to 1ºC at 34.0 to 34.5ppt (generally >0ºC) | 0.8 to 2ºC at 34.6 to 34.7ppt |
| **Water Zone III (Transition)** | **Backwards broad J-shape** | | |

| | | | |
|---|---|---|---|
| Water with little evidence of a temperature minimum, mixing with Type 2 transition water, no CDW and temperature at depth generally >0ºC | 1 to >2ºC at 33.7 to 34.0ppt | -0.5 to 0.5ºC at 34.3 to 34.4ppt (note narrow salinity range) | ≤ 1ºC at 34.7ppt |
| **Water Zone IV (Bransfield Strait)** | **Elongated S-shape** | | |
| Water with deep temperature near -1ºC, salinity 34.5ppt, cooler surface temperatures. | 1.5 to >2ºC at 33.7 to 34.2ppt | -0.5 to 0.5 ºC at 34.3 to 34.45ppt (T/S curve may terminate here) | <0ºC at 34.5ppt (salinity < 34.6ppt) |
| **Water Zone V (Weddell Sea)** | **Small fish-hook shape** | | |
| Water with little vertical structure and cold surface temperatures near or < 0ºC. | 1ºC (+/- some) at 34.1 to 34.4ppt | -0.5 to 0.5ºC at 34.5ppt | <0ºC at 34.6ppt |

The frontal region was narrow and distinct north of Livingston and King George Islands, broader between King George and Elephant Islands, and extended to the northern edge of the survey grid north of Clarence Island (Figure 1.3). This is consistent with observations on previous AMLR surveys. Water Zone I, indicative of the Antarctic Circumpolar Current, was mapped to the north of the frontal region and extended as far east as 54.4 W, where the frontal region appeared to be curved to the north and west thus enclosing a tongue of Water Zone I. This is more evident on the February 2000 SeaWiFS imagery (Figure 2.5, phytoplankton section) where a tongue of blue (low chlorophyll) water extends across the northern side of the South Shetland Islands as far east as Elephant Island, and is enclosed by an area of green and yellow (higher chlorophyll) water further to the east and north. Because the prevailing flow direction is southwest to northeast, it is hypothesized that the area of higher chlorophyll was entrained in a counter-clockwise eddy north of Elephant Island, and that this eddy was sustained by northward flow of eastern Bransfield Strait water (Water Zone IV) between Elephant and Clarence Islands and by northward flow of Weddell Sea water (Water Zone V) east of Clarence Island.

Cross sections of temperature and salinity also describe the location and intensity of the frontal region (Figure 1.4). Winter water, with a core at approximately 100m depth, and CDW, with a core at approximately 400m depth, are also apparent in the cross-sections. Maps of temperature at 100m depth and 400m depth indicate that cold Winter Water was most evident north of Livingston and King George Islands, and that the southern edge of warmer CDW diverged offshore north of Elephant Island (Figure 1.5).

**1.4 Disposition of Data:** Data are available from David A. Demer, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA, 92037; phone/fax (858) 546-5603/(858) 546-5608; email: ddemer@ucsd.edu.

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**1.6 References:**

M. Brown. 1998. Ocean data View 4.0. *Oceanography* 11(2): 19-21.

D. Benigni, D. Shields, T. Stepka and J. Brockett. September 1999. *Scientific Computer Ssytem (SCS) Version 2.3 for Windows NT 4.0.* National Oceanic and Atmospheric Administration, Marine and Aircraft Operations, Software Engineering Division, Silver Spring, Maryland.

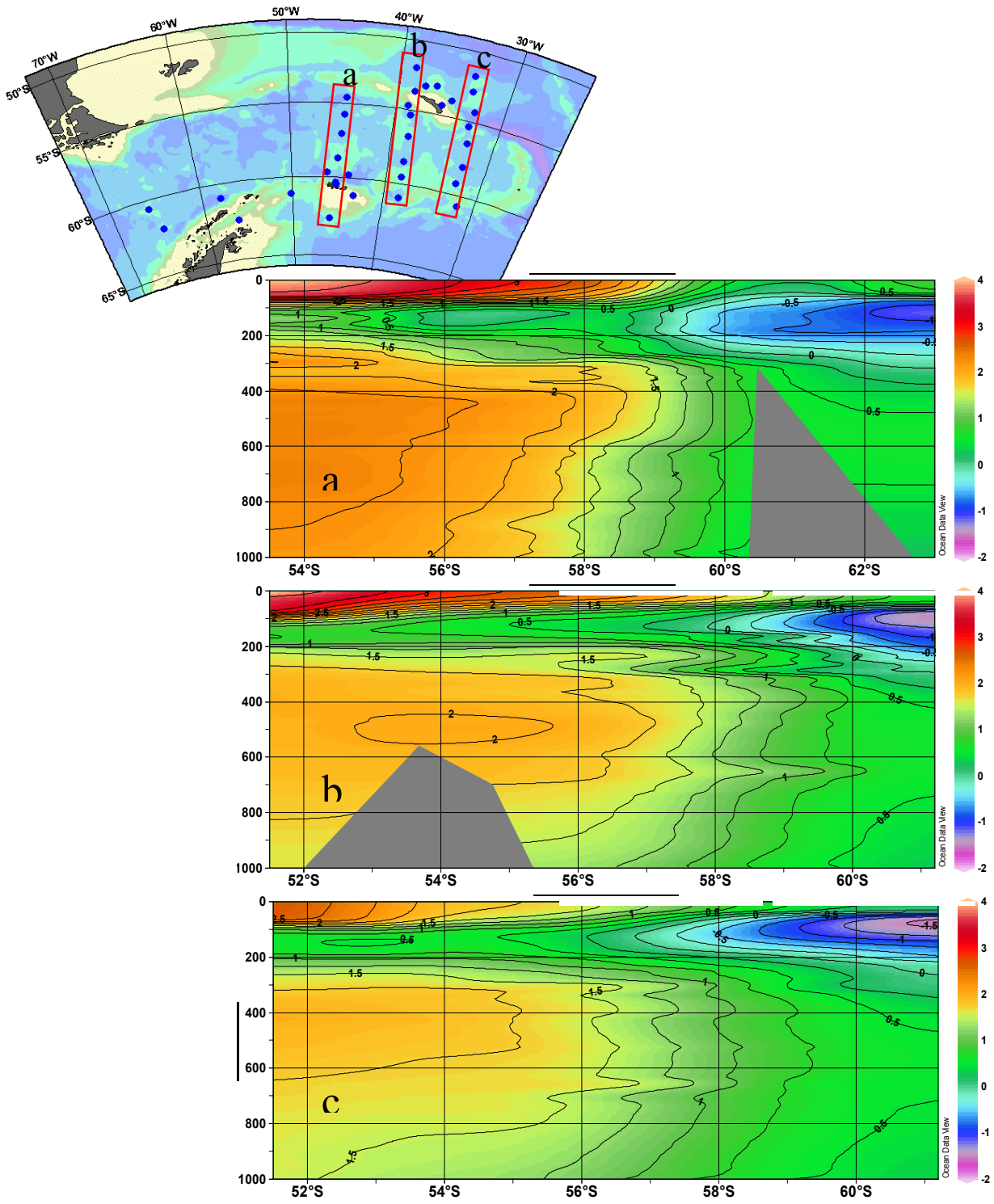


Figure 1.1 CCAMLR 2000 survey temperature cross-sections (Leg I).

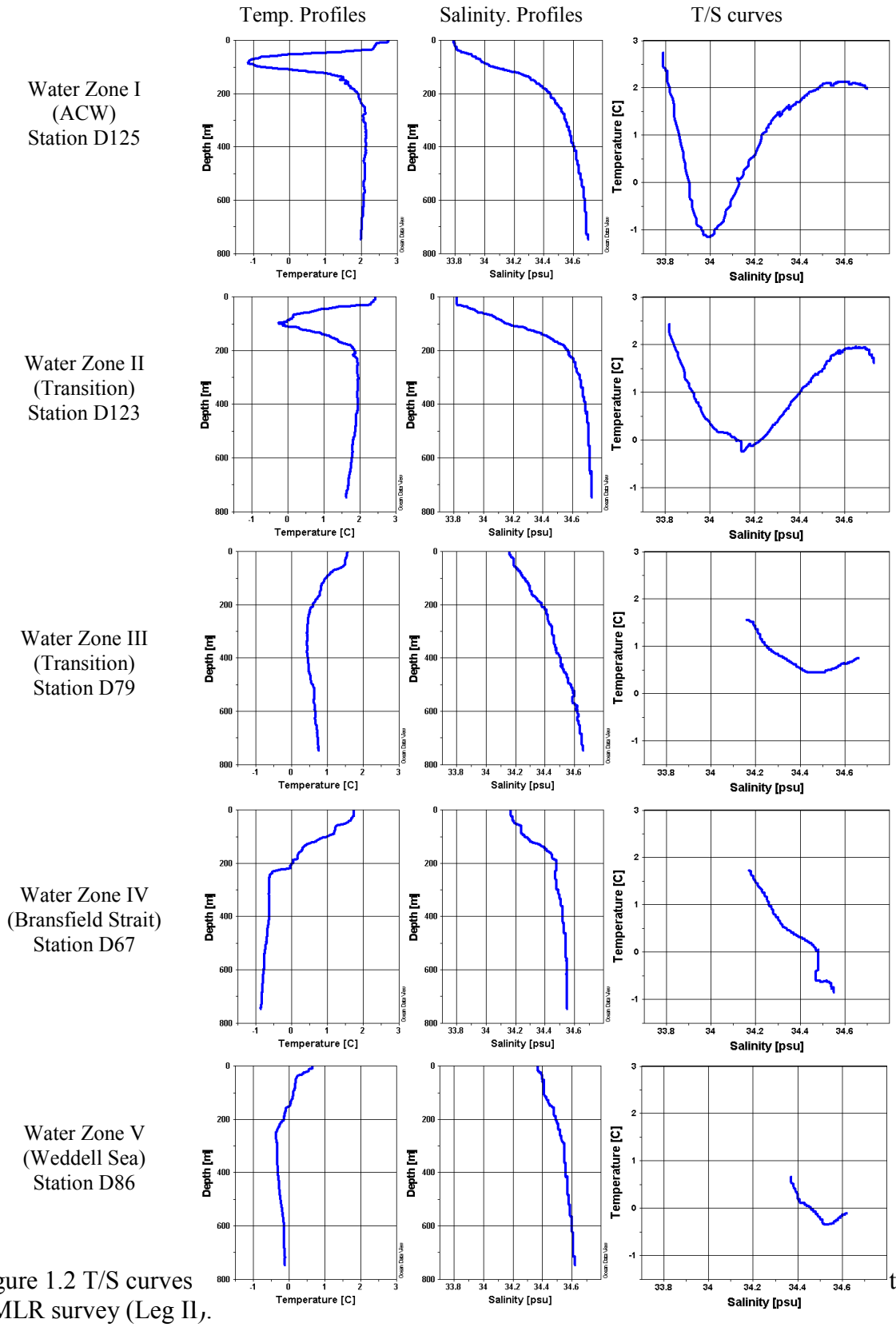


Figure 1.2 T/S curves the AMLR survey (Leg II).

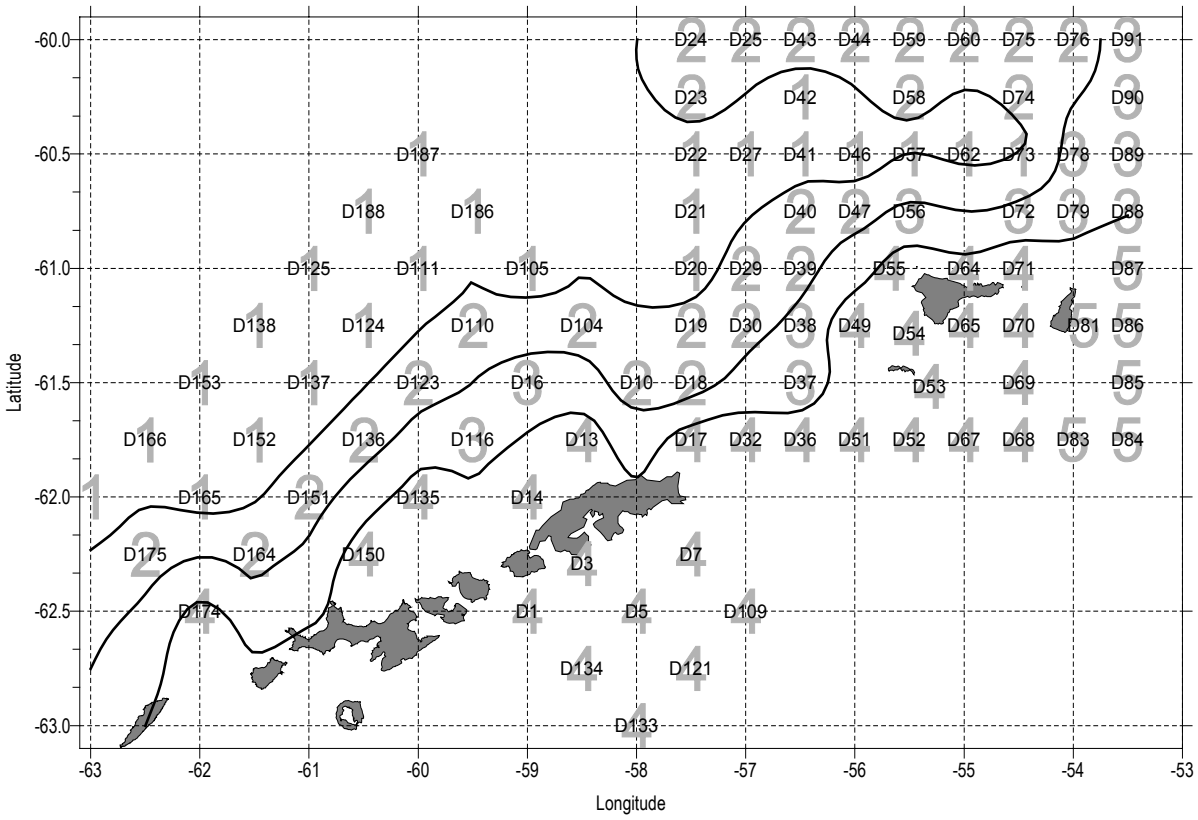


Figure 1.3 Geographic distributions of water zone types in during the AMLR survey (Leg II).

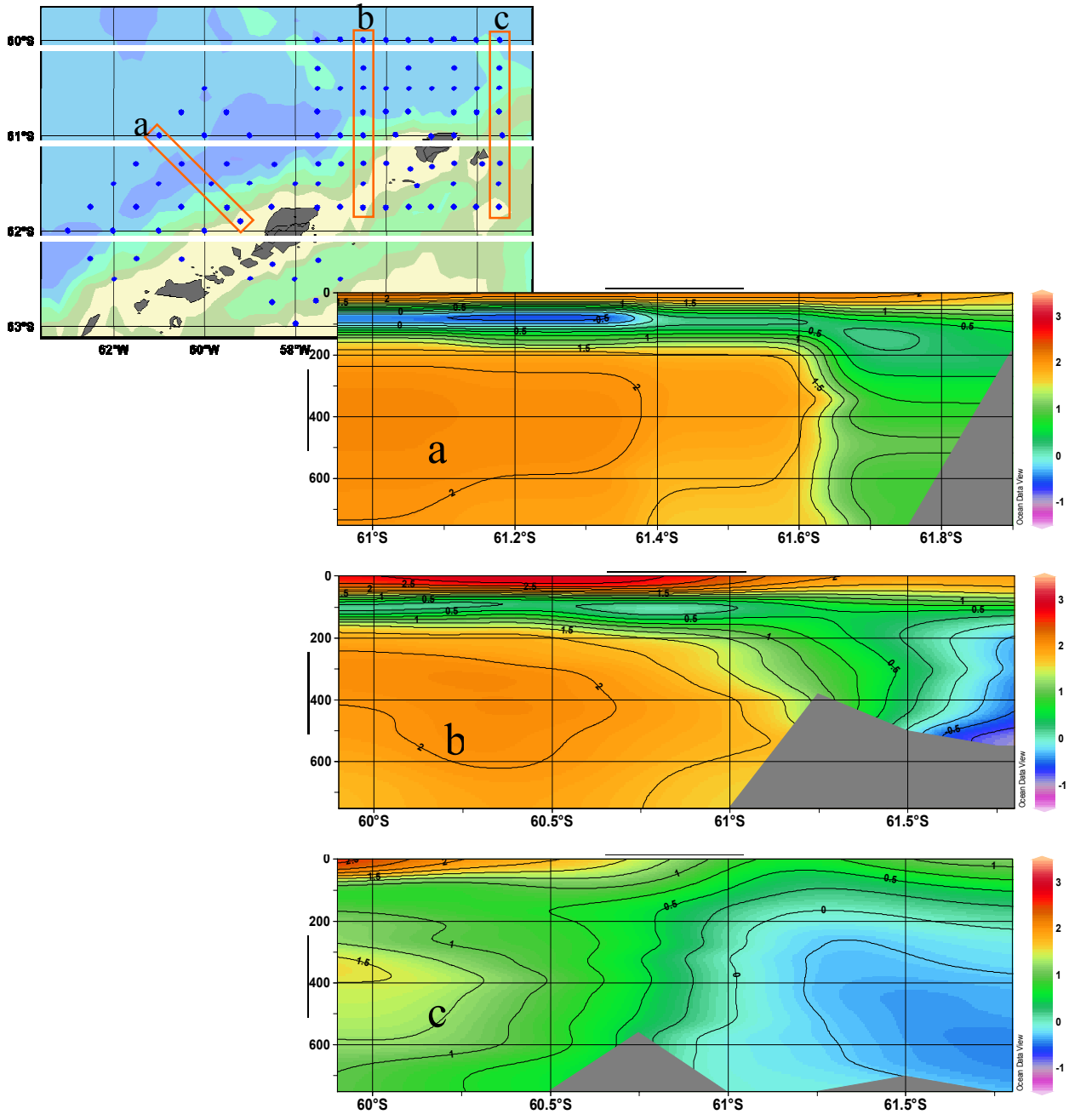


Figure 1.4 Selected temperature cross-sections during the AMLR survey (Leg II).

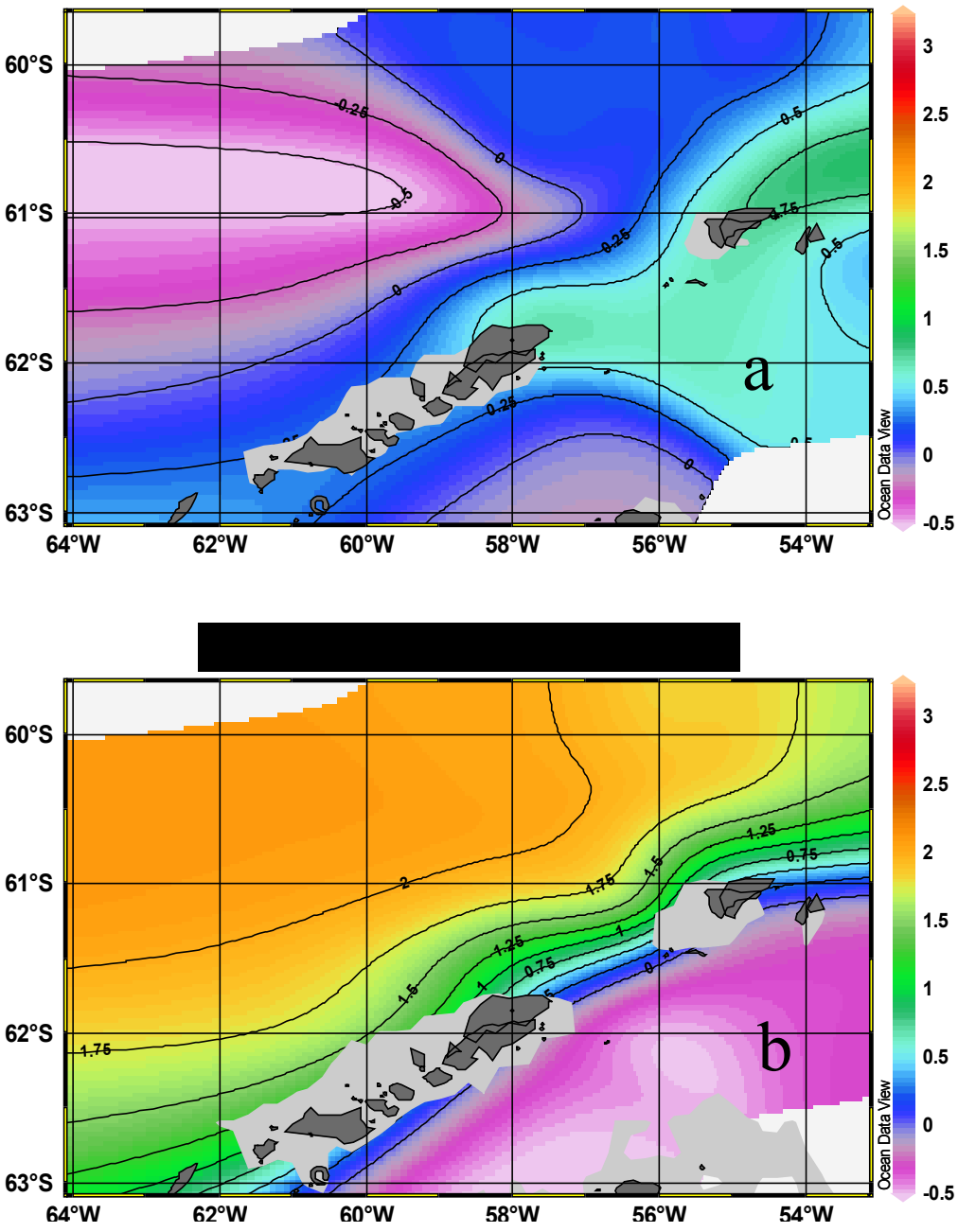


Figure 1.5 Temperature at 100m (a) and 500m (b) depths during the AMLR survey (Leg II).